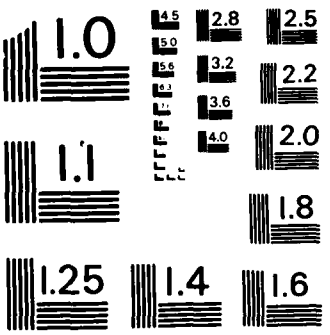
AD-A169 730 DEVELOPMENT OF A MICROCOMPUTER-BASED ADAPTIVE TESTING SYSTEM PHASE II IMPLEMENTATION(U) ASSESSMENT SYSTEMS CORP ST PAUL MN C D VALE 11 NOV 85 ASC-85-5-ONR 1/1

UNCLASSIFIED N00014-83-C-0634 F/G 9/2 NL



Research Report ONR-85-5

DEVELOPMENT OF A MICROCOMPUTER-BASED ADAPTIVE TESTING SYSTEM

PHASE II -- IMPLEMENTATION

C. David Vale

Assessment Systems Corporation
2233 University Avenue, Suite 310
St. Paul, MN 55114

December 1985

Final Report for Period 1 October 1983 to 11 November 1985.

This research was sponsored by the Personnel and Training Research Program, Psychological Sciences Division, Office of Naval Research, under Contract No. 00014-83-C-0634, Contract Authority Identification No. NR 507-002.

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT approved for public release; distribution unlimited
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) ONR-85-5	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Assessment Systems Corporation 6b. OFFICE SYMBOL (*If applicable*)	7a. NAME OF MONITORING ORGANIZATION Office of Naval Research
6c. ADDRESS (*City, State, and ZIP Code*) 2233 University Avenue, Suite 310 St. Paul, MN 55114	7b. ADDRESS (*City, State, and ZIP Code*) 800 N. Quincy Street, Code 442 Arlington, VA 22217
8a. NAME OF FUNDING / SPONSORING ORGANIZATION Personnel and Training Research 8b. OFFICE SYMBOL (*If applicable*)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N00014-83-C-0634
8c. ADDRESS (*City, State, and ZIP Code*) Office of Naval Research 800 N. Quincy Street, Code 442 Arlington, VA 22217	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. N 507-002 / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (*Include Security Classification*)
Development of a Microcomputer-Based Adaptive Testing System

12. PERSONAL AUTHOR(S)
C. David Vale

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (*Year, Month, Day*)	15. PAGE COUNT
technical report	FROM 9/1/83 TO 11/11/85	85 Nov 11	7

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (*Continue on reverse if necessary and identify by block number*)
FIELD	GROUP	SUB-GROUP	adaptive testing, computerized testing, diagnostic testing, MicroCAT, tailored testing, test development, testing hardware, testing software

19. ABSTRACT (*Continue on reverse if necessary and identify by block number*)

The goal of this project was to develop an inexpensive, self-contained system of hardware and software to support the development, administration, and evaluation of computerized adaptive tests. Toward that goal, commercial hardware was selected and a comprehensive software system called the MicroCAT™ Testing System was developed. The MicroCAT system was implemented in a local area network configuration at the Basic Electricity and Electronics School of the Naval Training Center in San Diego. It was integrated into the school's computer-managed instruction system and made available to the University of Illinois for research on adaptive diagnostic testing. In response to suggestions from users at this and other non-government implementations, the MicroCAT system was refined into a marketable commercial product.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION	
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Charles E. Davis	22b. TELEPHONE (*Include Area Code*) 202-696-4046	22c. OFFICE SYMBOL

ABSTRACT

The goal of this project was to develop an inexpensive, self-contained system of hardware and software to support the development, administration, and evaluation of computerized adaptive tests. Toward that goal, commercial hardware was selected and a comprehensive software system called the MicroCAT^{tm} Testing System was developed. The MicroCAT system was implemented in a local area network configuration at the Basic Electricity and Electronics School of the Naval Training Center in San Diego. It was integrated into the school's computer-managed instruction system and made available to the University of Illinois for research on adaptive diagnostic testing. In response to suggestions from users at this and other non-government implementations, the MicroCAT system was refined into a marketable commercial product.

TABLE OF CONTENTS

INTRODUCTION

Computerized adaptive testing offers a number of advantages over conventional testing including security, efficiency, and immediacy of results. However, adaptive tests must be administered on a computer, which can mean large expenditures for equipment and system development. The overall objective of this project was to ameliorate this problem by developing an inexpensive, self-contained system of hardware and software for the administration of a wide variety of tests.

The effort consisted of two contractually separate phases. During Phase I, a system was designed to facilitate the development and to support the administration of adaptive and conventional computerized tests. The system contained extensive facilities for entering test items, organizing them into adaptive and conventional tests, administering the tests, and analyzing the results. The design was documented by a preliminary user's manual.

Phase II of the effort had four objectives: 1) to select and procure computer hardware for implementing the system, 2) to implement on the selected hardware the software system described in the preliminary user's manual, 3) to install and field test the equipment at evaluation sites, and 4) to evaluate and refine the system based on feedback from the test sites. Progress toward each of these objectives is described below.

SELECTION OF THE HARDWARE

It was originally anticipated that the selection of the hardware would proceed in two stages. First, a list would be compiled including all of the computer hardware that could adequately administer psychological tests. In the second stage, three systems would be selected from the list and tested extensively. The evaluation was to have considered processing power, clarity of display, system reliability, and system durability.

By the time the Phase II contract was awarded, however, the microcomputer hardware environment had changed considerably. Many systems on the market could meet the minimum requirements for psychological testing. Processing power, display quality, and durability were no longer issues (although system reliability was still important). Two major new criteria had appeared, however: adherence to new industry standards, and manufacturer longevity. IBM had announced its personal computer some months previously, and it had become the de facto industry standard. Many small manufacturers of quality equipment had gone out of business, in part because of their lack of compatibility with IBM products.

It appeared to be a poor investment of time and equipment to extensively evaluate the performance capabilities of three different microcomputers when it was apparent that factors other than performance would determine the selection. Therefore, the selection was made on the basis of specification research. Seven factors were considered in selecting the hardware: computing power, mass storage capacity, graphics capability, networking capability,

manufacturer prominence, separation of disks from the display, and manufacturing site.

Computing power is essential in an adaptive testing system because a substantial amount of arithmetic computation must be performed for computing scores as well as for selecting items. Experience had shown that the Intel 8088 microprocessor, running at a clock speed of approximately 5 MHz, was capable of performing all adaptive testing functions in a single-user testing environment. Since this chip had become something of a standard in the microcomputer industry, acceptable computing power was loosely defined as power greater than or equal to that of the 8088.

Systems analysis in Phase I of this effort had suggested that mass storage approaching one megabyte would be required for adaptive testing. A number of computer manufacturers had adopted diskette drives capable of storing 320 to 360 kb. Although it was somewhat short of the one-megabyte requirement, a combination of two diskettes with a minimum of 320 kb each was established as the minimum standard.

Pixel graphics were required to represent drawings such as might be encountered in a test like the Armed Services Vocational Aptitude Battery (ASVAB). In general, the higher the resolution, the better the picture. A minimum standard of graphics resolution was set at 300 pixels horizontally and 200 pixels vertically.

The intended field test application was to require a network capable of supporting a minimum of 24 testing stations. The items would be kept on a hard disk at one of the stations and would have to be transmitted to each testing station, one at a time, upon demand. The minimum acceptable network was established as one that could support this many stations and transmit data fast enough that the worst case would not cause the system to slow down appreciably. Some simple arithmetic yielded a minimum acceptable network speed. Considering a worst case in which all stations would request items simultaneously, each item would contain one kilobyte of information, and the worst response time would be one second, the network bus speed had to be at least 0.192 megabits per second.

The preceding four factors were considered qualifier factors; a system had to be acceptable on all four to be considered. The remaining three were used to rank the acceptable candidates.

Prominence referred to the size of the manufacturer, the length of time the manufacturer had been making microcomputers or similar equipment, the number of microcomputers the manufacturer had delivered, and the perceived probability that the manufacturer would continue to make microcomputer equipment. This factor was considered important because it is difficult to obtain maintenance support for equipment that is no longer being manufactured or that was developed by a company that is no longer in business.

The ability to separate the diskette drives from the display and response device was considered important because there was some concern that examinees might put things into the diskette drives if they were openly visible and accessible. This would be especially important in a hostile environment that might surround the administration of some psychological tests.

The final factor, manufacturing site, was important because of government procurement regulations that might require some potential users to buy American-made equipment.

Four microcomputers were considered acceptable on all four qualifier factors. These were the IBM PC, the Texas Instruments Professional Computer, the Xerox 16/8, and the WICAT S-150. Of these, the IBM PC was ranked the highest. It differed from its two closest competitors (the Texas Instruments Professional and the Xerox 16/8) only in the prominence of the company as a manufacturer of computer equipment.

A final configuration was designed around the IBM PC and consisted of a network of testing stations communicating with two network servers. The connecting network selected was the 3COM Ethernet network. This network was selected because it was the only commercially available network that met the specifications and could be serviced on a national basis along with the computer equipment. The testing stations were configured as single-diskette computers. The servers were IBM PC-XT computers, each having a hard disk and a diskette drive.

Bids were then solicited from all vendors who could supply and maintain the equipment as required. Maintenance was a difficult requirement because, although the equipment was being purchased in Minnesota, all that was known at the time about its ultimate location was that it would not be Minnesota. Therefore, the vendor had to have a national maintenance network in place. Only two companies were able to respond at the time the bid was requested: Computerland and Sears. (IBM could not respond because the 3COM network was not an IBM product.) Computerland won the bid on the basis of its lower price.

Four computers were purchased immediately and assembled into a small version of the future testing network. The remaining computers were purchased later in the project when they were needed.

IMPLEMENTATION OF THE SOFTWARE

Although the basic design of the software was completed during Phase I of the effort and much of the software had been written at private expense between the project's two phases, substantial design and augmentation were required for the final system. The field test application was selected early in the project: the system would be used at the Basic Electricity and Electronics (BE&E) School at the Naval Training Center (NTC) in San Diego. It would be used to implement new forms of diagnostic testing being developed at the University of Illinois.

Meetings with Navy and University of Illinois personnel early in this phase of the project revealed two deficiencies in the system. First, it had no graphics capabilities. Graphics would be necessary to display the electronics items that would be administered in the BE&E School. The second deficiency was that the system could not specify tests using the new diagnostic algorithms that were being developed. To solve this problem, it was agreed that a custom interface would be added to the system so that procedures to implement these new techniques could be developed in FORTRAN or Pascal.

The majority of the design specified in Phase I had been implemented on a PDP 11 minicomputer. Software development for Phase II began by transferring these programs to the IBM personal computers and modifying them as necessary. In general, this was not a difficult task. The major changes were in version-specific Pascal differences and operating-system-specific function calls.

An initial version of a graphics editor was designed and developed. Several preliminary versions were delivered to the University of Illinois for evaluation. The final version allowed colored drawings to be developed interactively on the IBM PC using either a mouse or the arrow keys for cursor movement.

The design of the test development software provided for an authoring language to develop the tests and a compiler to translate the authoring language into a form that could be executed quickly. In the version developed for the IBM PC, the compiler also bit-maps and compresses the graphics items. While it might take as much as a minute for the computer to display an item using the graphics commands, the compressed bit-mapped version can be displayed in less than half a second.

The entire software system developed was described in the final *User's Manual for the MicroCAT Testing System*, distributed as Research Report ONR-85-1 (Assessment Systems Corporation, 1984). This manual contains an overview of computerized adaptive testing and discusses the many features of the MicroCAT™ Testing System in four sections corresponding to the four MicroCAT subsystems.

The section on the Development Subsystem describes the Graphics Item Banker, the font generator, creating tests from predefined test templates, and the test compiler. The section on the Examination Subsystem describes how to administer tests. The Assessment Subsystem section describes programs for collecting data from several administrations into a common file, performing conventional item analyses, estimating item response theory (IRT) item parameters, evaluating the adaptive potential of an item pool, and computing test validity coefficients. Finally, the section on the Management Subsystem describes programs that allow a network of testing stations to be managed from a single proctoring terminal.

The User's Manual also describes the practical details of the authoring language, MCATL (Minnesota Computerized Adaptive Testing Language). Further details about this authoring language are provided in Research Report

ONR-85-3, *MCATL: A Language for Authoring Computerized Adaptive Tests* (Vale, 1985b). This report describes the rationale for the development of elements of the language as well as its formal specification.

Research Report ONR-85-4, *ASCAL: A Microcomputer Program for Estimating Logistic IRT Item Parameters* (Vale & Gialluca, 1985), describes the technical details of ASCAL (for Assessment Systems CALibration), the IRT parameter program included in MicroCAT. ASCAL uses an algorithm very similar to the industry-standard calibration program LOGIST (Wingersky, Barton, & Lord, 1982). It differs from LOGIST in that it runs on a microcomputer and uses Bayesian prior distributions on several parameters. When it is run on an IBM PC with an 8087 math coprocessor, it performs a calibration of reasonable size (e.g., 35 items and 3,000 subjects) in a reasonable amount of time (e.g., less than two hours). When it is run without the coprocessor, the same calibration may take 24 hours.

FIELD TEST OF THE SYSTEM

Implementation of the MicroCAT system at the BE&E School began in June of 1984. A system consisting of 15 testing stations, two network servers, and one proctoring station was assembled. Several tests from the BE&E curriculum were implemented on the system for initial system evaluation.

The entire system was interfaced to MIISA, the mainframe computer in Memphis, Tennessee, which manages all of the instruction at NTC. To avoid reprogramming of MIISA (a task considered nearly impossible by NTC), the testing system was made to look like a GE Terminet terminal, from which MIISA was accustomed to receiving test results. Thus, MIISA was told to expect a new Terminet in the testing room, and the testing network was connected. This technique worked very well; the connection allowed the testing network to get test assignments from MIISA, and MIISA to get test results from the network. The only problem with this connection was that when MIISA failed, no new tests could be initiated until it was fixed. MIISA was the only non-redundant component in the testing system.

Details of the NTC implementation are described in Research Report ONR-85-2, *Implementation of a Microcomputer-Based Testing System in a Military Training Environment* (Vale, 1985a). This report provides details of how the MicroCAT system was adapted to the NTC implementation.

In addition to the NTC implementation, several MicroCAT systems were distributed to non-government users for use and evaluation. While the NTC implementation provided volume tests of the simple parts of the MicroCAT system, these other sites provided tests of the more advanced features of the system.

EVALUATION AND REFINEMENT OF THE SYSTEM

As the system was implemented at the evaluation sites, it was put to use almost immediately. In the early implementations, occasional bugs were found in the system. These were corrected as they were found.

More frequently, however, requests came for additional features in the system. The NTC implementation generated most of the initial requests. These included a request to allow the examinee to skip items early in the testing process and then return and answer them later. This feature was omitted originally because it is incompatible with adaptive testing. However, it is an important feature when the MicroCAT system is used for conventional testing.

Another feature that was implemented in response to requests from the field was the inclusion of high-resolution text-only items. The original system was intended only for medium-resolution graphics items. The addition of this feature made a wider range of textual items possible.

Other features have been suggested and will be implemented in the future. Split-screen text items, in which a reading passage scrolls in the top of the screen while a question remains stationary in the lower portion of the screen, have been partially implemented. Other features that may also be implemented include a hard-copy item banker and random item selection from a domain.

FUTURE PLANS

The MicroCAT Testing System, which was designed and refined in this project, is now a commercial software product. Although it was initially intended for a relatively small group of users (i.e., those who wanted to implement adaptive tests), it appears that the market is expanding. Several good suggestions obtained during the course of the contract will be implemented as revenues allow.

In its current state, MicroCAT is a well-tested, stand-alone adaptive testing system capable of administering a variety of adaptive tests. Since its support is now commercial, the additions that will be made first are those most in demand in the market. Specifically, since the education community appears to be one of the most promising markets, features such as sampling items from a domain, split-screen text items, and conventional item-banking capabilities will be added first. As revenues allow and research suggests, new item types and testing strategies will also be added.

REFERENCES

Assessment Systems Corporation. (1984). *User's manual for the MicroCAT Testing System* (Research Rep. No. ONR-85-1). St. Paul, MN: Author.

Vale, C. D. (1985a). *Implementation of a microcomputer-based testing system in a military training environment* (Research Rep. No. ONR-85-2). St. Paul, MN: Assessment Systems Corporation.

Vale, C. D. (1985b). *MCATL: A language for authoring computerized adaptive tests* (Research Rep. No. ONR-85-3). St. Paul: Assessment Systems Corporation.

Vale, C. D., & Gialluca, K. A. (1985). *ASCAL: A microcomputer program for estimating logistic IRT item parameters* (Research Rep. No. ONR-85-4). St. Paul, MN: Assessment Systems Corporation.

Wingersky, M. S., Barton, M. A., & Lord, F. M. (1982). *LOGIST user's guide.* Princeton, NJ: Educational Testing Service.

Distribution List

Personnel Analysis Division,
AF/MPXA
5C360, The Pentagon
Washington, DC 20330

Air Force Human Resources Lab
AFHRL/MPD
Brooks AFB, TX 78235

Dr. Earl A. Alluisi
HQ, AFHRL (AFSC)
Brooks AFB, TX 78235

Dr. Erling B. Andersen
Department of Statistics
Studiestraede 6
1455 Copenhagen
DENMARK

Dr. Phipps Arabie
University of Illinois
Department of Psychology
603 E. Daniel St.
Champaign, IL 61820

Technical Director, ARI
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Eva L. Baker
UCLA Center for the Study
of Evaluation
145 Moore Hall
University of California
Los Angeles, CA 90024

Dr. Isaac Bejar
Educational Testing Service
Princeton, NJ 08450

Dr. Menucha Birenbaum
School of Education
Tel Aviv University
Tel Aviv, Ramat Aviv 69978
ISRAEL

Dr. Arthur S. Blaiwes
Code N711
Naval Training Equipment Center
Orlando, FL 32813

Dr. R. Darrell Bock
University of Chicago
Department of Education
Chicago, IL 60637

Cdt. Arnold Bohrer
Sectie Psychologisch Onderzoek
Rekruterings-En Selectiecentrum
Kwartier Koningen Astrid
Bruijnstraat
1120 Brussels, BELGIUM

Dr. Robert Breaux
Code N-095R
NAVTRAEQUIPCEN
Orlando, FL 32813

Dr. Robert Brennan
American College Testing
Programs
P. O. Box 168
Iowa City, IA 52243

Dr. Patricia A. Butler
NIE Mail Stop 1806
1200 19th St., NW
Washington, DC 20208

Mr. James W. Carey
Commandant (G-PTE)
U.S. Coast Guard
2100 Second Street, S.W.
Washington, DC 20593

Dr. James Carlson
American College Testing
Program
P.O. Box 168
Iowa City, IA 52243

Dr. John B. Carroll
409 Elliott Rd.
Chapel Hill, NC 27514

Dr. Robert Carroll
NAVOP 01B7
Washington, DC 20370

Dr. Norman Cliff
Department of Psychology
Univ. of So. California
University Park
Los Angeles, CA 90007

Distribution List (Continued)

Director,
Manpower Support and
Readiness Program
Center for Naval Analysis
2000 North Beauregard Street
Alexandria, VA 22311

Dr. Stanley Collyer
Office of Naval Technology
Code 222
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Hans Crombag
University of Leyden
Education Research Center
Boerhaavelaan 2
2334 EN Leyden
The NETHERLANDS

CTB/McGraw-Hill Library
2500 Garden Road
Monterey, CA 93940

Dr. Dattprasad Divgi
Center for Naval Analysis
4401 Ford Avenue
P.O. Box 16268
Alexandria, VA 22302-0268

Dr. Hei-Ki Dong
Ball Foundation
800 Roosevelt Road
Building C, Suite 206
Glen Ellyn, IL 60137

Defense Technical
Information Center
Cameron Station, Bldg 5
Alexandria, VA 22314
Attn: TC
(12 Copies)

Dr. Stephen Dunbar
Lindquist Center
for Measurement
University of Iowa
Iowa City, IA 52242

Dr. James A. Earles
Air Force Human Resources Lab
Brooks AFB, TX 78235

Dr. Kent Eaton
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. John M. Eddins
University of Illinois
252 Engineering Research
Laboratory
103 South Mathews Street
Urbana, IL 61801

Dr. Susan Embretson
University of Kansas
Psychology Department
Lawrence, KS 66045

ERIC Facility-Acquisitions
4833 Rugby Avenue
Bethesda, MD 20014

Dr. Benjamin A. Fairbank
Performance Metrics, Inc.
5825 Callaghan
Suite 225
San Antonio, TX 78228

Dr. Leonard Feldt
Lindquist Center
for Measurement
University of Iowa
Iowa City, IA 52242

Dr. Richard L. Ferguson
American College Testing
Program
P.O. Box 168
Iowa City, IA 52240

Dr. Gerhard Fischer
Liebiggasse 5/3
A 1010 Vienna
AUSTRIA

Prof. Donald Fitzgerald
University of New England
Department of Psychology
Armidale, New South Wales 2351
AUSTRALIA

Mr. Paul Foley
Navy Personnel R&D Center
San Diego, CA 92152

Dr. Carl H. Frederiksen
McGill University
3700 McTavish Street
Montreal, Quebec H3A 1Y2
CANADA

Dr. Robert D. Gibbons
University of Illinois-Chicago
P.O. Box 6998
Chicago, IL 69680

Dr. Janice Gifford
University of Massachusetts
School of Education
Amherst, MA 01003

Dr. Robert Glaser
Learning Research
& Development Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15260

Dr. Bert Green
Johns Hopkins University
Department of Psychology
Charles & 34th Street
Baltimore, MD 21218

Dr. Ronald K. Hambleton
Prof. of Education & Psychology
University of Massachusetts
at Amherst
Hills House
Amherst, MA 01003

Ms. Rebecca Hetter
Navy Personnel R&D Center
Code 62
San Diego, CA 92152

Dr. Paul W. Holland
Educational Testing Service
Rosedale Road
Princeton, NJ 08541

Prof. Lutz F. Hornke
Universitat Dusseldorf
Erziehungswissenschaftliches
Universitatsstr. 1
Dusseldorf 1
WEST GERMANY

Dr. Paul Horst
677 G Street, #184
Chula Vista, CA 90010

Mr. Dick Hoshaw
NAVOP-135
Arlington Annex
Room 2834
Washington, DC 20350

Dr. Lloyd Humphreys
University of Illinois
Department of Psychology
603 East Daniel Street
Champaign, IL 61820

Dr. Steven Hunka
Department of Education
University of Alberta
Edmonton, Alberta
CANADA

Dr. Huynh Huynh
College of Education
Univ. of South Carolina
Columbia, SC 29208

Dr. Robert Jannarone
Department of Psychology
University of South Carolina
Columbia, SC 29208

Dr. Douglas H. Jones
Advanced Statistical
Technologies Corporation
10 Trafalgar Court
Lawrenceville, NJ 08148

Dr. G. Gage Kingsbury
Portland Public Schools
Research and Evaluation Department
501 North Dixon Street
P. O. Box 3107
Portland, OR 97209-3107

Dr. William Koch
University of Texas-Austin
Measurement and Evaluation
Center
Austin, TX 78703

Distribution List (Continued)

Dr. Leonard Kroeker
Navy Personnel R&D Center
San Diego, CA 92152

Dr. Michael Levine
Educational Psychology
210 Education Bldg.
University of Illinois
Champaign, IL 61801

Dr. Charles Lewis
Faculteit Sociale Wetenschappen
Rijksuniversiteit Groningen
Oude Boteringestraat 23
9712GC Groningen
The NETHERLANDS

Dr. Robert Linn
College of Education
University of Illinois
Urbana, IL 61801

Dr. Robert Lockman
Center for Naval Analysis
4401 Ford Avenue
P.O. Box 16268
Alexandria, VA 22302-0268

Dr. Frederic M. Lord
Educational Testing Service
Princeton, NJ 08541

Dr. James Lumsden
Department of Psychology
University of Western Australia
Nedlands W.A. 6009
AUSTRALIA

Dr. William L. Maloy
Chief of Naval Education
and Training
Naval Air Station
Pensacola, FL 32508

Dr. Gary Marco
Stop 31-E
Educational Testing Service
Princeton, NJ 08451

Dr. Clessen Martin
Army Research Institute
5001 Eisenhower Blvd.
Alexandria, VA 22333

Dr. James McBride
Psychological Corporation
c/o Harcourt, Brace,
Javanovich Inc.
1250 West 6th Street
San Diego, CA 92101

Dr. Clarence McCormick
HQ, MEPCOM
MEPCT-P
2500 Green Bay Road
North Chicago, IL 60064

Mr. Robert McKinley
University of Toledo
Department of Educational Psychology
Toledo, OH 43606

Dr. Barbara Means
Human Resources
Research Organization
1100 South Washington
Alexandria, VA 22314

Dr. Robert Mislevy
Educational Testing Service
Princeton, NJ 08541

Headquarters, Marine Corps
Code MPI-20
Washington, DC 20380

Dr. W. Alan Nicewander
University of Oklahoma
Department of Psychology
Oklahoma City, OK 73069

Dr. William E. Nordbrock
FMC-ADCO Box 25
APO, NY 09710

Dr. Melvin R. Novick
356 Lindquist Center
for Measurement
University of Iowa
Iowa City, IA 52242

Director, Manpower and Personnel
Laboratory,
NPRDC (Code 06)
San Diego, CA 92152

Distribution List (Continued)

Library, NPRDC
Code P201L
San Diego, CA 92152

Commanding Officer,
Naval Research Laboratory
Code 2627
Washington, DC 20390

Dr. James Olson
WICAT, Inc.
1875 South State Street
Orem, UT 84057

Office of Naval Research,
Code 1142PT
800 N. Quincy Street
Arlington, VA 22217-5000
(6 Copies)

Special Assistant for Marine
Corps Matters,
ONR Code 00MC
800 N. Quincy St.
Arlington, VA 22217-5000

Dr. Judith Orasanu
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Wayne M. Patience
American Council on Education
GED Testing Service, Suite 20
One Dupont Circle, NW
Washington, DC 20036

Dr. James Paulson
Department of Psychology
Portland State University
P.O. Box 751
Portland, OR 97207

Dr. Roger Pennell
Air Force Human Resources
Laboratory
Lowry AFB, CO 80230

Dr. Mark D. Reckase
ACT
P. O. Box 168
Iowa City, IA 52243

Dr. Malcolm Ree
AFHRL/MP
Brooks AFB, TX 78235

Dr. Carl Ross
CNET-PDCD
Building 90
Great Lakes NTC, IL 60088

Dr. J. Ryan
Department of Education
University of South Carolina
Columbia, SC 29208

Dr. Fumiko Samejima
Department of Psychology
University of Tennessee
Knoxville, TN 37916

Mr. Drew Sands
NPRDC Code 62
San Diego, CA 92152

Dr. Robert Sasmor
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Mary Schratz
Navy Personnel R&D Center
San Diego, CA 92152

Dr. W. Steve Sellman
OASD(MRA&L)
2B269 The Pentagon
Washington, DC 20301

Dr. Kazuo Shigemasu
7-9-24 Kugenuma-Kaigan
Fujusawa 251
JAPAN

Dr. William Sims
Center for Naval Analysis
4401 Ford Avenue
P.O. Box 16268
Alexandria, VA 22302-0268

Dr. H. Wallace Sinaiko
Manpower Research
and Advisory Services
Smithsonian Institution
801 North Pitt Street
Alexandria, VA 22314

Dr. Richard Sorensen
Navy Personnel R&D Center
San Diego, CA 92152

Dr. Paul Speckman
University of Missouri
Department of Statistics
Columbia, MO 65201

Dr. Martha Stocking
Educational Testing Service
Princeton, NJ 08541

Dr. Peter Stoloff
Center for Naval Analysis
200 North Beauregard Street
Alexandria, VA 22311

Dr. William Stout
University of Illinois
Department of Mathematics
Urbana, IL 61801

Maj. Bill Strickland
AF/MPXOA
4E168 Pentagon
Washington, DC 20330

Dr. Hariharan Swaminathan
Laboratory of Psychometric and
Evaluation Research
School of Education
University of Massachusetts
Amherst, MA 01003

Mr. Brad Sympson
Navy Personnel R&D Center
San Diego, CA 92152

Dr. Kikumi Tatsuoka
CERL
252 Engineering Research
Laboratory
Urbana, IL 61801

Dr. Maurice Tatsuoka
220 Education Bldg
1310 S. Sixth St.
Champaign, IL 61820

Dr. David Thissen
Department of Psychology
University of Kansas
Lawrence, KS 66044

Mr. Gary Thomasson
University of Illinois
Educational Psychology
Champaign, IL 61820

Dr. Robert Tsutakawa
The Fred Hutchinson
Cancer Research Center
Division of Public Health Sci.
1124 Columbia Street
Seattle, WA 98104

Dr. Ledyard Tucker
University of Illinois
Department of Psychology
603 E. Daniel Street
Champaign, IL 61820

Dr. Vern W. Urry
Personnel R&D Center
Office of Personnel Management
1900 E. Street, NW
Washington, DC 20415

Dr. David Vale
Assessment Systems Corp.
2233 University Avenue
Suite 310
St. Paul, MN 55114

Dr. Frank Vicino
Navy Personnel R&D Center
San Diego, CA 92152

Dr. Howard Wainer
Division of Psychological Studies
Educational Testing Service
Princeton, NJ 08541

Dr. Ming-Mei Wang
Lindquist Center
for Measurement
University of Iowa
Iowa City, IA 52242

Mr. Thomas A. Warm
Coast Guard Institute
P. O. Substation 18
Oklahoma City, OK 73169

Dr. Brian Waters
Program Manager
Manpower Analysis Program
HumRRO
1100 S. Washington St.
Alexandria, VA 22314

Dr. David J. Weiss
N660 Elliott Hall
University of Minnesota
75 E. River Road
Minneapolis, MN 55455

Dr. Ronald A. Weitzman
NPS, Code 54Wz
Monterey, CA 92152

Major John Welsh
AFHRL/MOAN
Brooks AFB, TX 78223

Dr. Rand R. Wilcox
University of Southern
California
Department of Psychology
Los Angeles, CA 90007

German Military Representative
ATTN: Wolfgang Wildegrube
Streitkraefteamt
D-5300 Bonn 2
4000 Brandywine Street, NW
Washington, DC 20016

Dr. Bruce Williams
Department of Educational
Psychology
University of Illinois
Urbana, IL 61801

Dr. Hilda Wing
Army Research Institute
5001 Eisenhower Ave.
Alexandria, VA 22333

Dr. Martin F. Wiskoff
Navy Personnel R & D Center
San Diego, CA 92152

Mr. John H. Wolfe
Navy Personnel R&D Center
San Diego, CA 92152

Dr. George Wong
Biostatistics Laboratory
Memorial Sloan-Kettering
Cancer Center
1275 York Avenue
New York, NY 10021

Dr. Wendy Yen
CTB/McGraw Hill
Del Monte Research Park
Monterey, CA 93940

END

DTIC

8-86